DOCUMENT RESUME

ED 239 877 SE 043 833

AUTHOR Dube, Peter
TITLE What Makes Things Happen? Teacher's Guide. Unit B. ZIM-SCI, Zimbabwe Secondary School Science Project.
INSTITUTION Ministry of Education and Culture (Zimbabwe).; Zimbabwe Univ., Harare. Science Education Centre.
PUB DATE Mar 81
NOTE 20p.; See SE 043 832 for study guide; for related documents, see SE 043 827-859.
AVAILABLE FROM University of Zimbabwe, P.O. Box MP 167, Mount Pleasant, Harare, Zimbabwe.
PUB TYPE Guides - Classroom Use - Guides (For Teachers) (052)

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS *Energy; Fuels; General Science; *Power Technology; *Science Activities; Science Education; *Science Experiments; Secondary Education; *Secondary School Science; Solar Energy; Teaching Methods; Units of Study
IDENTIFIERS Alternative Energy Sources; *Zimbabwe Secondary School Science Project

ABSTRACT

The Zimbabwe Secondary School Science Project (ZIM-SCI) developed student study guides, corresponding teaching guides, and science kits for a low-cost science course which could be taught during the first 2 years of secondary school without the aid of qualified teachers and conventional laboratories. This teaching guide, designed to be read in conjunction with the related student guide, includes instructional strategies, lists of required materials, laboratory procedures, and other information for activities and experiments in a unit on energy. During the unit, students observe what is happening around them, relate their observations to energy, complete experiments on forms of energy (including heat, light, kinetic, electrical, and potential energy), and investigate energy conversions, energy chains, and alternative energy sources (hydroelectricity and solar energy). Two summaries are included to highlight the important aspects of the unit. Each section in this guide corresponds to a given section in the student study guide. (JN)

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Zim-Sci team: Alan Dock (Project Leader)
Peter Dube
Bunty Hosking
Gift Jambaya
Sue Stocklmayer
Dave Wright

Main Writer of this unit: Peter Dube

Acknowledgement

We are grateful for the ready cooperation and assistance we have received from the Audio Visual department of the Ministry of Education and Culture in the preparation of art work.

March 1981

GENERAL SCIENCE

UNIT B : WHAT MAKES THINGS HAPPEN ?

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AIMS

EXTRACTED FROM THE SYLLABUS

At the end of this unit pupils will be able to:

(i) describe energy in operational terms

(ii) state several different forms of energy

(iii) state ways in which energy may be converted from one form to another

(iv) describe the changes by which all forms of energy (except atomic) originate from solar energy falling on the earth

(v) state those energy sources which are renewable and those which are limited and no longer being renewed

(vi) give examples of the release of energy from certain chemical structures by chemical action

(vii) identify food intake as a process which releases energy to living organisms

(viii) identify carbon as the common element present in all foods

(ix) construct an energy chain for plant materials and food derived from plant materials, starting with the sun.

TEACHER'S GUIDE

WHAT MAKES THINGS HAPPEN?

This unit is meant to be completed in two weeks. So by the end of the first week the work up to the end of Experiment 7 ought to have been completed.

The unit starts by asking the pupils to observe what is happening around them and these observations are related to energy. Energy is thus discussed in terms of changes which the pupils observe.

In the first part of the unit, your pupils will DO experiments on heat energy, light energy, motion or kinetic energy, electrical energy and stored or potential energy. After these, experiments on energy conversions follow and energy chains are established.

Your pupils will be aware that their daily activities, for instance, running, playing and working require energy which they get from their food. They will be aware that their food comes from plants in one form or another, but, very few of them will associate their food with the sun at this stage.

Sources of energy are then discussed, starting with food, then coal and oil and their origin traced to the sun.

The last section is on alternative sources of energy for example hydroelectricity and solar energy.

Two summaries have been included to highlight the important aspects of the unit. The completed energy tables, the pupils' table (blank) and answers to exercises are included in your guide.

Before starting the experiments draw the blank energy table on the blackboard and ask the pupils to copy it into their exercise books.

BLANK TABLE TO BE DRAWN ON THE BOARD

EXERCISE 1

Experiment No.	Page	What is causing change	Change caused	Forms of energy observed
1	4			
2	5			
3	7			
4	8			
5	9			
6	10			
7	11			
8	12			
9	13			
10	14			
11	14			
12	15			

EXPERIMENT 1

Each pair of pupils requires: a piece of magnesium ribbon

Before this lesson begins, cut pieces of magnesium metal each 2 cm long and place them on your table in the evaporating dish for pupils to collect. Ask one of each pair to come up and collect it while the other one gets out the basic kit apparatus.
Remind the pupils not to look directly at burning magnesium because the very bright flame could damage their eyes.

Tell them to fill in the line for Experiment No. 1 in the table after completing the experiment. For your reference a completed table with possible answers is included in this guide after Experiment 12.
The idea is that pupils associate energy with change and in this experiment the changes involved heat and light energy. The pupils see the intense light and feel the hot stand...

EXPERIMENT 2

Each pair of pupils will need:

a piece of paper (an old newspaper will do)
a thread
Also provide your scissors

Cut pieces of thread each 10 cm long and place them on your table together with the pair of scissors for the pupils to collect and use in turn. Only having one pair of scissors may cause delay here, so if you can borrow extra scissors for this experiment it will help. Pupils will need help in drawing the spiral and cutting along the spiral line. They will also need help in stretching the spiral out. Show them how to tie the spiral.

Warn the pupils that their spiral will burn if they hold it too near the flame.

When they have observed the spiral burning tell them to fill in line No. 2 in the table. The idea is that pupils see the change in the spinning of the spiral. It turns slowly then fast. This change involves kinetic energy which comes from the heat in the flame.

EXPERIMENT 3

A simple experiment. The pupils will only need a ruler.

Very often pupils enjoy making noise this way, but be careful not to annoy the neighbours!

The idea is that the pupils feel themselves "putting" energy on the ruler and that the ruler produces sound as it vibrates.

Tell them to fill in line No. 3 in the table.

EXPERIMENT 4

Each pair of pupils will need:

- a piece of copper wire
- a torch bulb
- a torch battery

Before this lesson begins cut pieces of copper wire 10 cm long. The wire is painted and will need to be scraped on each end to allow good electrical connections. Place the prepared wire on your table in the evaporating dish together with torch bulbs and torch batteries for pupils to collect.

Pupils may need help in connecting up a complete circuit. The object of the experiment is to make the bulb light. The pupils will also feel the heat from the bulb if they allow it to glow for long enough. Your pupils will be tempted to repeat the experiment over and over again. Don't let this go on too long, as the batteries have limited energy.

N.B.

The idea is that pupils observe where the energy to light and heat the bulb comes from. They must see that it is the battery which makes things happen and that a complete circuit is necessary. Tell them to fill in No. 4 in the table.
Collect and keep the pieces of copper wire, they will be needed again.

EXPERIMENT 5

Each pair of pupils requires:

- evaporating dish
- potassium manganate (probably labelled potassium permanganate)
- a dropper
- glycerol
- water

Each pair must receive from you:

- 2 spatulas of potassium manganate in their evaporating dishes. They must use a dropper to add glycerol to the potassium manganate.

Warn the pupils not to touch potassium manganate crystals because the substance stains the skin badly. If staining does happen it will wear off in a few days and is not harmful. After the experiments they must wash the evaporating dishes and droppers with water. They must use pieces of paper for cleaning the dishes.
This experiment produces a lot of heat energy. The potassium manganate also changes its colour. Pupils may need to add a drop or two of water to start the reaction.
Tell them to fill in Line No. 5 and then write exercise 2 in their books.

Exercise 2 Describe everything you observed in Experiment 5.

Exercise 2 Answer

The main idea is that pupils see that the energy causing the changes comes from mixing potassium manganate and glycerol. The energy is stored in these chemicals as chemical energy and it is shown as heat energy during the reaction.
In this description they should include the change in colour of potassium manganate and the heat they felt at the bottom of the evaporating dish.

EXPERIMENT 6

Each pair requires:

- a rubber band
- a small stone (they must find this from the garden)
- a piece of string

Cut pieces of string about 5 cm long and place them on your table together with rubber bands. One pupil from each pair can collect the string and rubber band while the other goes out to find a stone.

The pupils might need help in tying the rubber band to the stone. Emphasize the stone must be securely attached to the rubber band to avoid accidents.

Tell the pupils to fill in line No. 6 in the table, after completing the experiment.

The purpose of this experiment is for pupils to feel themselves "putting" energy in stretching the rubber band.
They must feel that the stretched rubber has energy stored in it. This energy is capable of moving the stone.

EXPERIMENT 7

Another simple experiment which is best done outside the classroom. The pupils should find a large stone they can lift.

Tell them to fill in line No. 7 in the energy table after carrying out the experiment. Pupils feel their energy being put into the stone as they lift it. They must also feel the effect of gravity as the stone is moved down. They will also feel their arms getting tired because they are putting their energy into the stone, suggesting that their muscles are temporarily running out of energy.

EXPERIMENT 8

This is a "thinking experiment" in which you ask your pupils to close their eyes and then tell them an imaginary story. The story may go like this:

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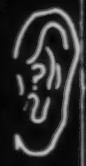
"You have been sent by your mother to go and fetch some water from a well with her best clay pot. On your way home the pot slips off your head, falls to the ground and breaks to pieces".



Discuss with the pupils what happens in the story and try to get them to suggest that potential energy stored in the lifted pot is changed to kinetic energy as it falls and then to sound and more kinetic energy in the flying pieces and moving water!

Now tell them to fill in line No. 8 in the energy table. The idea is that pupils imagine the energy changes the pot goes through. Point out to them that the water takes some of the energy as it flows away. Ask them where this energy might go.

EXPERIMENT 9

You will demonstrate this experiment so your pupils will come to your table.

You will need.

a bicycle dynamo assembly (made up of a dynamo, bulb and wire)

a stone about 1 kg in mass
a cotton thread 1½ m long
a retort stand

Refer to Diagram 7 on page 13 in the study guide.

1. Clamp the dynamo onto the retort stand on your table. Ask pupils if they recognise the dynamo and ask them what it does.
2. Then tie the stone to one end of the thread and tie the other end of the thread to the dynamo using the small hole at its end.
3. Wind the thread onto the dynamo until the stone is above the table as shown in Diagram 7 on page 13 in the study guide. Ask the pupils what will happen when the stone is dropped.
4. Then let the stone drop.

The bulb lights when the stone drops. If it does not light check the electrical connections. If it still does not light test the bulb by connecting it to a battery.

Discuss the energy changes involved in the demonstration repeating it if necessary to make the points clear. They must see where the energy comes from and where it goes to.

Now tell the pupils to fill in line No. 9 in the table and answer Exercise 3 in their exercise books.

Exercise 3. Draw the energy chain for Experiment 9.

We suggest you draw the empty boxes and ask pupils to copy them into their exercise books. The pupils then fill in the energy change and what is happening in each box.

EXERCISE 3 Answer

potential energy (stone held up)	→	kinetic energy (stone falling)	→	electrical energy (dynamo turning)	→	light and heat energy (bulb lighting)

EXPERIMENT 10

You will demonstrate this experiment in the sun outside your classroom. You will need:

solar cells, normally used for charging your battery

two pieces of copper wire (used in Experiment 4 in the study guide)

a motor

1. Connect the solar cells to the motor with copper wire as shown in Diagram 8 on page 14 in the study guide.
2. Place the whole unit in the sun and let the pupils observe what happens. Experiment with shading the solar cells partially and then completely to show the pupils where the energy is coming from. If the weather is cloudy this experiment may not work.

After returning to the classroom tell them to complete line 10 in the energy chart.

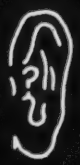
SOLAR CELLS

Solar cells are a new invention in energy conversion. They convert solar energy to electrical energy which moves the motor.

It is expected by scientists that solar energy is going to be more and more important as a renewable source of energy.

Its worth spending some time letting pupils experiment with different ways of trapping the solar energy of light and heat. e.g. Your pupils can do simple experiments to use solar heat energy. If you are short of time, you need not do the experiments described.

One interesting experiment is to light a match or burn a piece of paper with a hand lens. To do this they hold a match stick or piece of paper and then focus the sun's rays on the match stick head or piece of paper. As you know the focal point is hot because it concentrates the heat energy falling on the whole lens onto one spot and so it will light the match or burn the paper.



They can do another experiment using two plastic bags. They paint one of the plastic bags with black powder or blackboard paint and leave the other unpainted. Then half fill each bag with water and take the temperature of the water in both bags. They then tie the bags with string so that the water does not leak away. Then they place the two bags in the sun outside the classroom. They measure the temperature of the water in the bags just before the school breaks for lunch. The water in the black bag will be hotter than that in the unpainted bag. Both bags absorb solar energy but the black bag does so faster than the unpainted bag.

Find out about solar heaters and talk to the pupils about them. Some of your pupils might want to make solar heaters. Give them as much help as you can.

If they are interested in making a simple solar heater the following things are required:

1. A plate (may be made of wood) with pipes or channels through which heat can flow. This collects energy from the sun.
2. Heat insulation on the bottom of the plate to reduce loss of heat.
3. A glass or plastic covering for the front of the plate to further reduce heat loss.
4. A storage vessel for the hot water.

EXPERIMENT 11

This is another demonstration experiment by you and you will need:

Your rechargeable battery
the electric motor
the pieces of copper wire used in Experiment 10
the same stone and thread used in Experiment 9 on page 13 in the study guide.

1. Place the motor on your table such that the small pulley (wheel) projects beyond the edge of the table. See Diagram 9 page 14 in the study guide.
2. Tie the end of the thread onto the pulley and wind a bit of it into the pulley groove.
3. With the stone on the floor connect the motors to the battery (the object is to make the motor lift the stone).

Again discuss the energy changes and tell the pupils to complete line 11 in the table. Here pupils see where the energy to lift the stone comes from and where it goes, and that the motor used in this way converts electrical energy to kinetic energy.

EXPERIMENT 12

This is a continuation of Experiment 11, in which we want to show the pupil that the motor can also convert energy in the opposite direction.

You replace the battery with a torch bulb.
See Diagram 10 page 15, so you will need:

a piece of copper wire
a torch bulb

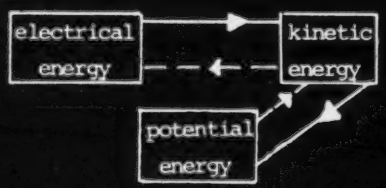
1. With the stone on the table connect the torch bulb to the motor with a piece of copper wire as shown in Diagram 10 page 15.
2. Then let the stone drop. (The bulb should light).

By now the pupils should be able to describe the energy changes happening. Tell the pupils to fill in line 12 in the table.

EXERCISE 4

Construct a reversible energy chain from what you observed in Experiments 11 and 12.

EXERCISE 4 Answer



The pupils may need your help here in understanding the two ways in which the motor can act as an energy converter. The pupils should see that the motor converts electrical to kinetic energy in Experiment 11 and converts kinetic to electrical in Experiment 12 and that an energy chain is produced in each case.

This is the end of the series of simple experiments on energy and here is a completed table to help you check the pupils' work.

COMPLETED TABLE FOR MARKING

Experiment No.	Page	What is causing change	Change caused	Forms of energy observed
1	4	magnesium and air	stand hot room bright	heat, light
2	5	burner flame	spiral spins fast	kinetic
3	7	you	ruler moved up and down, noise produced	kinetic sound
4	8	circuit	bulb lit bulb hot	heat, light
5	9	mixture of potassium manganate & glycerol	potassium manganate became brown evaporating dish becomes hot	heat
6	10	you	rubber band stretched	kinetic
7	11	you, gravity	stone lifted stone dropped	kinetic, sound
8	12	you, gravity	pot lifted pot dropped	kinetic, sound
9	13	stone dropping	dynamo turned bulb lit	kinetic, light heat
10	14	solar cell	motor turned	kinetic
11	14	battery	motor turned stone lifted	kinetic
12	15	stone dropping	motor turned bulb lit	kinetic, light

These experiments help the pupils understand where most of our energy on this planet comes from.

EXPERIMENT 13

Each pair of pupils will need:

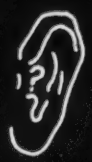
4 spatulas mealie meal in their evaporating dish

They must heat the mealie meal until it starts to burn or else it will not catch fire when they light it. Make sure the pupils realise heat and light energy are released by the burning mealie meal.
Write Exercise 5 on the blackboard for pupils to answer in their books.

Exercise 5. In your exercise books describe how you did the experiment.

The description should follow the sequence in Experiment 13 on page 17 in the study guide. Emphasize that they must describe the experiment in their own words and not just copy Experiment 13. The idea is to show that carbohydrates give out heat when they burn.

It is necessary to relate this energy stored in carbohydrates with the energy stored in fuels. Tell them how coal and oil were formed. Here is some information to help you.



There are large quantities of Coal at Wankie. Big forests grew in the area millions of years ago. (1 million is 1 000 000 years) The trees died and fell to the ground. In this way large piles of trees were formed. With time, these piles of trees were buried deep in the ground by soil and rocks. If you have seen Coal you will be surprised that it does not look like the wood you know. The wood gradually changed slowly into coal. Heat energy and pressure caused the change deep in the ground. So at Wankie large stores of energy trapped in the trees laid down millions of years ago are dug up today.

The Oil that buses and cars use daily does not look like the animal material from which it was formed. Small animals and plants lived under the sea millions of years ago. The small animals ate the small sea plants. The seas then dried up. All the animals and plants remained at the bottom. Later, they were buried and were slowly changed to oil by chemical reactions.

You will have noticed that there is something in common in both these energy sources. They both started with plants.

This experiment helps the pupils understand the next important step in the energy chain.

EXPERIMENT 14

For this experiment the pupils will use the plants they grew in Unit A2.

They placed one lot of plants in a dark place. They placed the other lot where there was sunlight. The plants grown in the dark should look thin, pale green and generally unhealthy, because they are unable to make their food in the dark. Those in sunlight should look green, normal and generally healthy, because they are able to make food in the sun.

The pupils then answer Exercise 6 in their books.

Exercise 6. Look at each of the plants in Experiment 14 and make a list of all the differences you notice.

One way is to draw two columns like this:

Plants in the dark	Plants in the sun
Tall and thin	normal
Leaves pale green	leaves dark green
Leaves thin	leaves normal
look unhealthy	look healthy
stem thin	stem normal

There could be other differences pupils will observe. Ask them to write down as many as they can.

EXPERIMENT 15

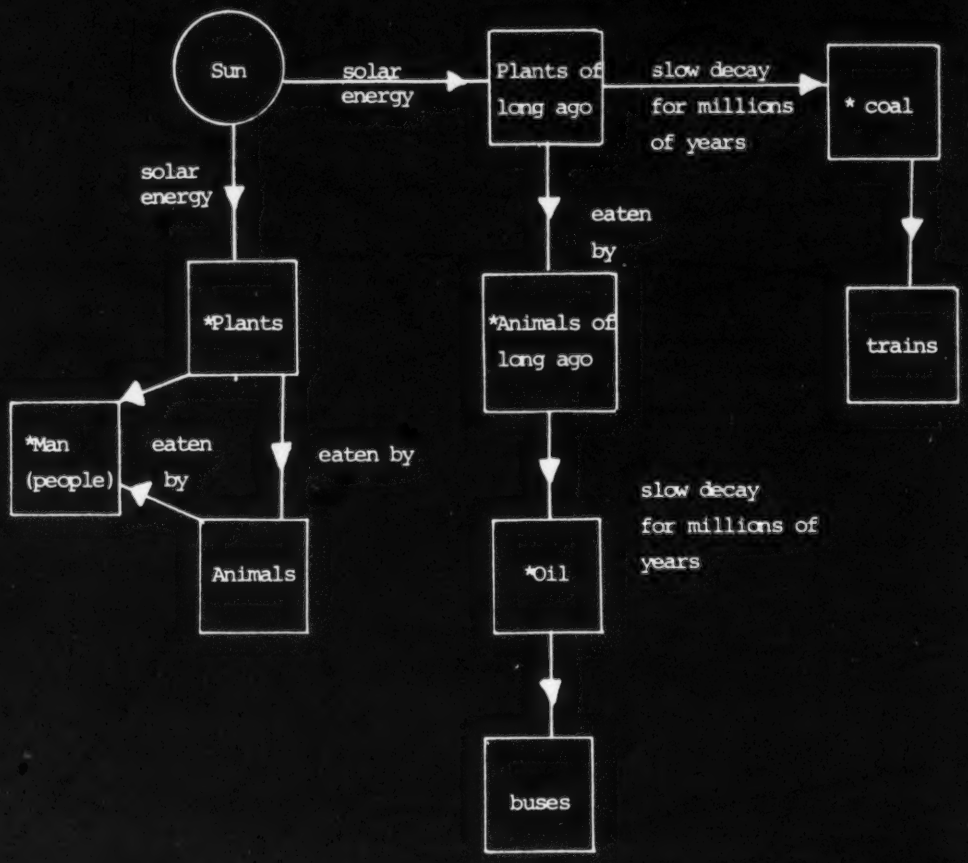
Here is another simple experiment. The pupils must look at the water towards the end of the lesson. The water will have disappeared into the air if it is hot enough. If not, they could leave it until the end of the morning or till the next day.

The experiment is meant to show the evaporation which takes place in dams and the sea.

To summarise the whole unit pupils should now carry out Exercise 7.

EXERCISE 7

Draw the diagram shown below on the blackboard, ask the pupils to copy it into their exercise books and tell them to fill in the empty boxes.



* These boxes should be left empty when you draw this diagram on the board.